

AMERICAN SOCIETY OF CIVIL ENGINEERS.

INSTITUTED 1852.

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No. 847.

THE APPROACHES AND TRANSPORTATION FACILITIES OF THE PARIS EXPOSITION OF 1900.*

By E. L. CORTHELL, M. Am. Soc. C. E.

PRESENTED FEBRUARY 15TH, 1899.

During a recent visit to Paris, the author became much interested in the engineering features of the Paris Exposition of 1900, and undertook to collect, for presentation to this Society, such information as was obtainable on certain interesting and important points.

The engineers in charge of the several works, fully understanding this purpose, afforded him every facility for inspection, and kindly furnished plans, reports and other data.

The Exposition of 1889 occupied the Trocadero grounds and the Champs de Mars. The special, or rather the grand, feature of that Exposition was the Eiffel Tower, and, as secondary only, the Palais des Machines. These two structures were the only ones preserved. The latter is to be remodeled in its interior by preserving a great central space as a Salle des Fêtes, the remainder of the building being devoted to the Agricultural Exhibit.

* It has been found impossible to reproduce all the plans, drawings, etc., accompanying this paper, but they are all filed in the Library of the Society for reference. A list of the Exhibits will be found at the end of the paper.

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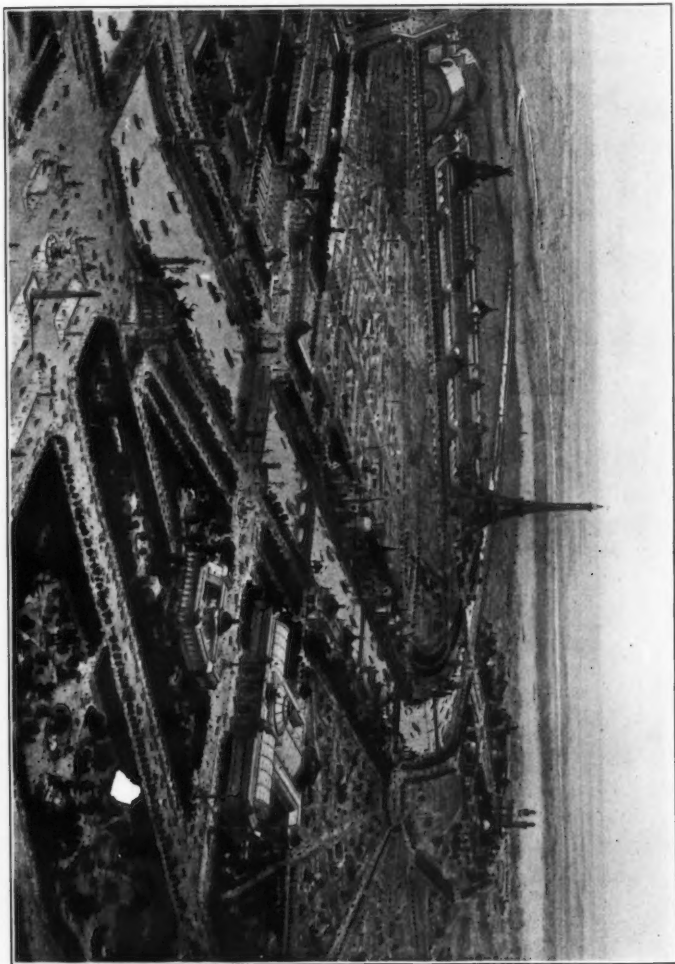
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PLATE V.
TRANS. AM. SOC. CIV. ENGRS.
VOL. XLI, No. 847.
CORTHELL ON PARIS EXPOSITION.





The Eiffel Tower has been kept in use all the time. Recently, various experiments have been made to determine the best color for repainting it. After many trials with various tints it has been decided to paint it sky-blue, in order to make it as inconspicuous as possible, it being thought that, in the clear days which may be expected generally during the Exposition, this color will blend with the blue of the sky and make the tower less prominent.

As it is the desire of the architects to make electricity the main exhibit, and to attract for it the greatest attention, the Electricity Building will be the most striking object to meet the eye of the visitor. The bird's-eye view, Plate V, shows this building standing in the center of the Champs de Mars, in its longer dimension, and near the Salle des Fêtes.

An outline map of Paris is shown on Plate VI.

A greater area for the Exposition than that of 1889 has been provided, by taking the Gardens of the Hotel des Invalides, and also an area on the right bank of the Seine, now occupied by the old Palace of Industry, which is soon to be removed. Two beautiful permanent stone Art Palaces, the larger and the smaller, are nearing completion on this ground. Between them is to be opened a broad avenue leading from the Avenue des Champs Élysées over the river and up to the elevated plateau immediately in front of the Hotel des Invalides. This new avenue will present a striking artistic feature of the Exposition, and will remain as one of the most beautiful avenues of the city. It seemed proper that the bridge to be built across the Seine, to connect the two parts of this avenue, should be made a monumental structure and one of the principal features of the Exposition.

Another quite extensive area has been provided along the left bank of the river, connecting the Champs de Mars and the Gardens of the Invalides—the two main parts of the Exposition on that side. This strip of land which has been reclaimed from the Seine by a very substantial masonry wall, is about 100 ft. wide, and will be occupied mostly by the government buildings of the various countries of the world. The bird's-eye view, while in some respects imaginative, shows how cosmopolitan will be this strip of land. Underneath this strip, and about through its center, has been built a double-track railroad subway, by which the Western Railroad will traverse the entire front of the grounds and reach its large and permanent low-

level station along the Quai d'Orsay and under the Gardens of the Invalides. After reaching the Pont des Invalides, or just before reaching it, the railroad, by reversed curves, passes under the first building marked on the map "Gare des Invalides," and then spreads out into quite wide station grounds, and reaches the opposite side of the Gardens, where it has a duplicate station, both stations being permanent stone structures.

The features thus briefly referred to can be better understood by examining the sketch of the Exposition grounds (Fig. 1), on which the subway above mentioned and the arrangement of the tracks at the Gare des Invalides are shown by heavy dotted lines.

The following works will now be described in the order named:

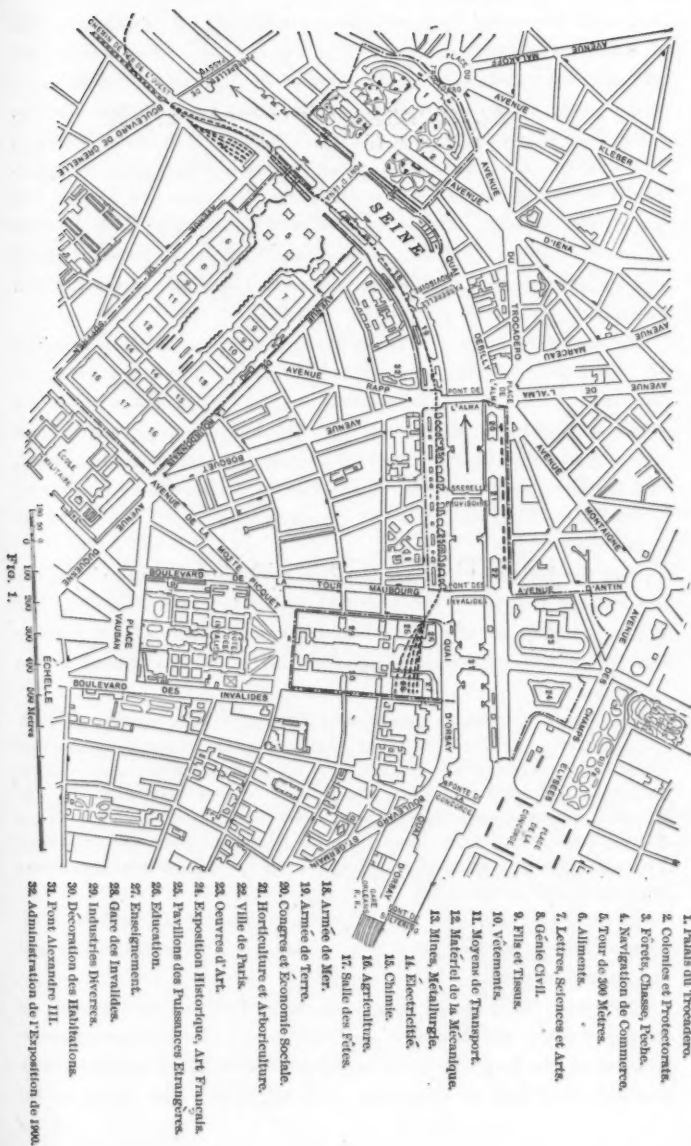
1. The Alexander III Bridge.
2. The Extension of the Orleans Railroad toward the Exposition Grounds.
3. The Extension of the Western Railroad to the Exposition.
4. The Plateforme Mobile (Movable Sidewalk) and Electric Railroad.
5. The Metropolitan Underground Electric Railway.
6. The Enlargement of the Gare de Lyons of the Paris, Lyons and Mediterranean Railway.

THE ALEXANDER III BRIDGE.

As the *Annales des Ponts et Chaussées* contain detailed descriptions of this bridge, it would be superfluous to more than briefly mention this very interesting work. Some of its features are quite extraordinary, and will be worthy of careful study by those specially interested in ornamental bridge construction on an extensive scale.

Mr. Alby, the Resident Engineer, requested the author to present to the Society the photographs shown in Plate VII. These photographs show the elevation of the bridge and a section through one of the abutments, and, though made prior to the construction of the bridge, they are correct, except as to some unimportant features of the abutments, which developments during the preliminary work made it necessary to change.

It may not be generally known that in 1823 a project for a suspension bridge at this location was brought forward and finally approved,



and, after two years' work and the expenditure of a considerable sum of money, was nearly finished. This was in 1826. Upon putting the cables in tension and laying the floor of the bridge, the joints in the upper seats of the counterforts of the right bank opened slightly. Some days afterward a water conduit nearly broke in two. No doubt this damage could have been easily repaired, but it gave an opportunity to the opponents of the structure, who were not pleased with its artistic features, the towers obstructing the view of the façade of the Hotel des Invalides, to renew their efforts to have the bridge condemned. It was decided to abandon the work and remove it entirely.

A suspended structure, constructed near by in 1829, transformed in 1854 into a masonry bridge and called the Pont des Invalides, has, until recent years, been ample for the traffic, but, with the increase of traffic, the congestion over the Pont de la Concorde, next above, made it necessary to provide another structure between the two, and the location in extension of the Rue de Constantine was selected, as the Palais d'Industrie blocked the way for one at the location of the demolished bridge.

But the decision to remove the Palais d'Industrie and to build two Art Palaces in these grounds as features of the 1900 Exposition, led to the adoption of the present location, and it was also decided to build a great architectural structure. As is well expressed in the memoire:

"Le choix de l'emplacement de l'Exposition Universelle de 1900, qui a entraîné la démolition du palais de l'Industrie et l'ouverture d'une large avenue entre les Champs-Élysées et l'Esplanade des Invalides, a fait nécessairement abandonner le projet du pont de Constantine et comprendre dans le programme des travaux de l'Exposition une traversée de la Seine dans l'axe de la nouvelle avenue, traversée d'un caractère monumental en raison du rôle qu'elle est appelée à jouer dans un ensemble décoratif."

As is well known, the Czar of Russia, Alexander III, laid the foundation stone of this bridge, on the occasion of his visit to Paris, and this gave it its name.

The plans were under consideration in 1895, by the Minister of Public Works, the Minister of Commerce and the Commissioner-General of the Exposition. The matter was referred to the Conseil-Général des Ponts et Chaussées in June, 1896. The plans of the

OUTLINE MAP OF PARIS

METRES
1 500 400 300 200 100

EXPLANATION

*Extension of the Western and Orleans
Railways*

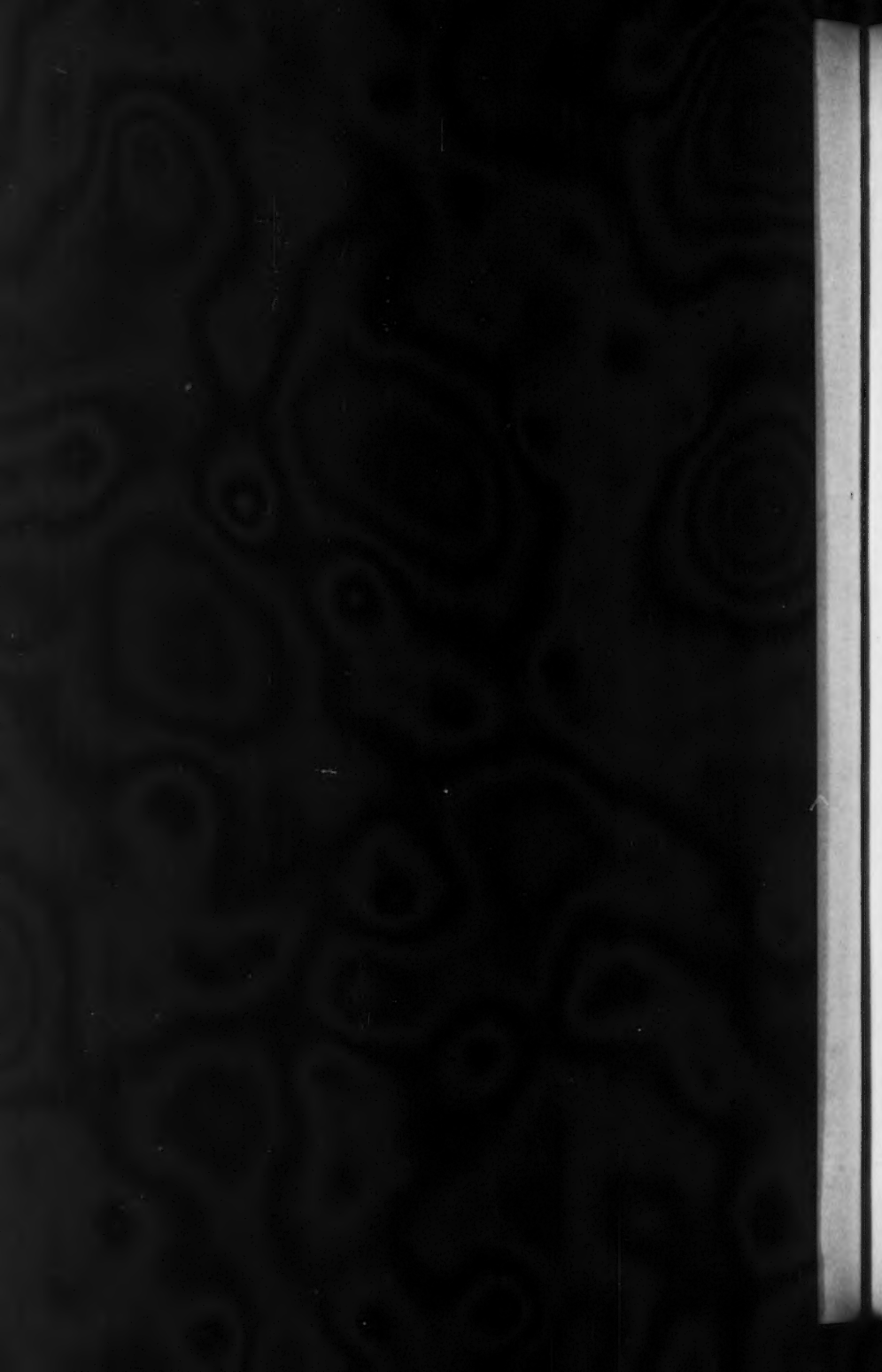
Metropolitan R.R. routes





PLATE VI.
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foundations were approved in January, 1897, and of the superstructure in July of the same year.

The architectural features—the decorative parts—were worked out later by the architects, Messrs. Rénard and Cousin, with a view of harmonizing the entire structure with the architecture of the Exposition and other features of the locality. There were three points to consider: *First*, not to interfere with the perspective of the Invalides, viewed from the Champs-Élysées; *second*, not to injure the appearance of the Seine, seen from the Pont de la Concorde; *third*, to make the width in proportion to the width of 100 m. (328 ft.) of the new avenue. On the other hand, the width of clear span for navigation must take into account a bend in the river at the location, which throws the current upon the right bank. To restrict the width at this point would seriously interfere with the navigation by convoy. Very laborious study was given to all these points. In the structure, as finally designed, all these requirements have been met.

The type of the bridge is that of three articulations. The principal features of alignment and dimensions are as follows:

The longitudinal axis corresponds with that of the new avenue, requiring a slight skew with the face of the abutments, which are parallel to the navigable channel of the river.

The width of the river between the two quays is 155 m. (508.5 ft.). The abutments project somewhat, so that the articulations of the two ends are 107.50 m. (352.69 ft.) apart.

The width of the bridge is 40 m. (131.2 ft.) between guards; a central roadway of 20 m. (65.6 ft.) and two sidewalks, each of 10 m. (32.8 ft.). The grade toward the center is 2%, joined by a vertical curve of 32 m. (104.99 ft.) chord and of 800 m. (2 624 ft.) radius.

The curve of the cross-section of the roadway is also of 0.20 m. (0.656 ft.) rise.

The metallic structure is composed of fifteen arches, or ribs, equally spaced. These ribs are of cast steel; the superstructure, floor, etc., are of rolled steel, and the decorative parts are castings.

As the river could not be obstructed an entire year, during the erection of the structure, it became necessary to devise some means of erection to avoid this. For this reason the ribs are united by bolts rather than by rivets, and the erection is performed by means of a traveler which spans the river, moving on wheels, on tracks laid on

each abutment. This traveler, Figs. 2 and 3, moves down stream from each set of two ribs to another set—a veritable rolling bridge.

The flatness of the arch, necessitated by the reasons already stated, is one of the unique features of the structure. The axes of the end articulations are 2.25 m. (7.38 ft.) above the normal level of the water

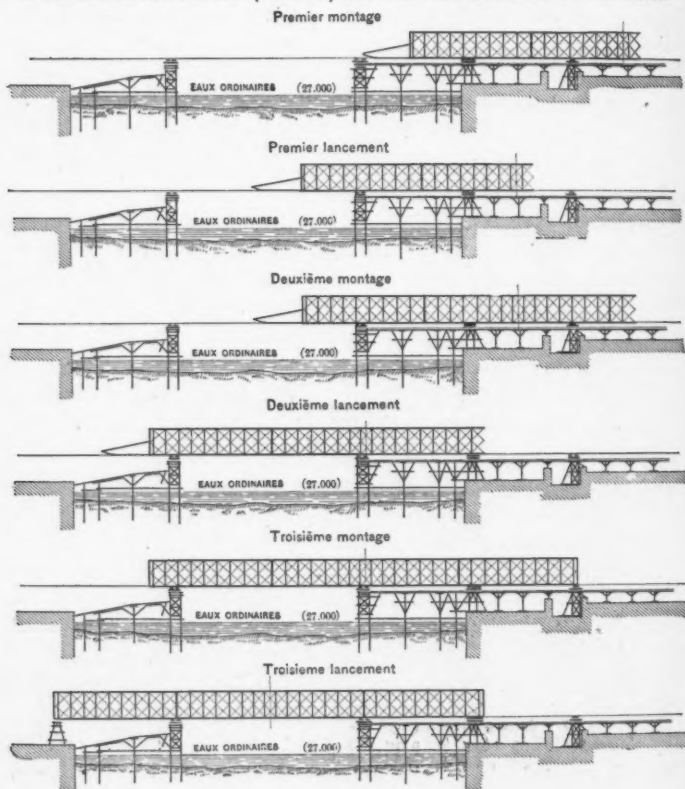
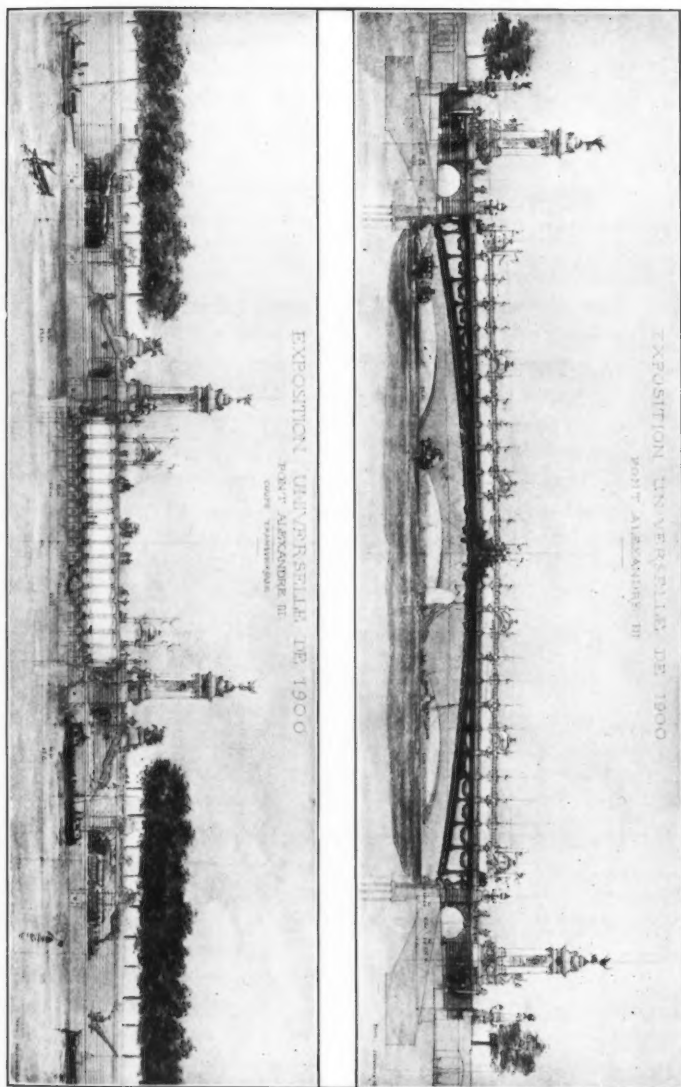


FIG. 2.

and the articulation at the center is 8.53 m. (27.98 ft.) above the same level. The ratio of rise to length is 1 to 17.12.

The foundation work was not only very interesting, but somewhat difficult to manage, on account of the great size of the abutments. Owing to the flatness of the arch, the thrust is very great, 288 tons per





square meter (10.76 sq. ft.). The thrust by the first plan was 345 tons per square meter, and the ratio of rise to span was 1 to 20.

The endeavor to reduce the pressure has been constant, on account of the anxiety caused by the character of the subsoil, due to the settlements in the other old bridges nearby, built, but afterward removed.

The abutments are parallelograms, 33.50 m. (109.88 ft.) with the axis of the bridge and 44 m. (144.36 ft.) with the axis of the river. Each of these immense abutments was founded on a single caisson, divided into five parts by partitions perpendicular to the direction of the river. Above the working chambers there was a metallic truss-work parallel to the direction of the river. The working chambers, and the truss-work as well, are filled with béton in the proportion of 3 volumes of Seine gravel to 2 volumes of mortar. The mortar is mixed in the proportion of 450 kgr. (992.25 lbs.) of Portland cement to 1 cu. m. (1.31 cu. yds.) of sand. The mean thickness of the béton is 3.40 m. (11.144 ft.). All the upper part of the abutment is of masonry. There are on the face three courses of granite, each 0.50 m. in height, and above them a molded granite course, upon which rests directly the masonry for the skewbacks of the arch. These and other details are shown in Fig. 4.

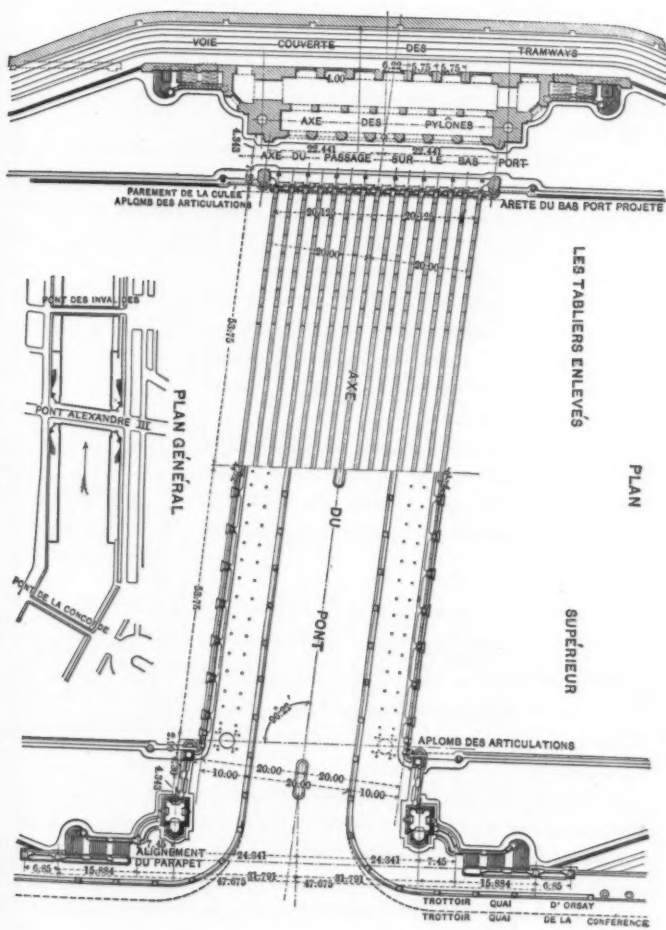
In the execution of the work it was decided to build and sink the caissons in place without dredging. The metallic structure of the caissons is soft steel. The general features, as well as some details showing the air-locks and shafts, of which there were ten, are shown on Exhibit F 4.* The height of the caisson proper was only 3.68 m. (12.07 ft.). The exterior walls were carried up by prolonging the sides as the caisson sank, as shown in Fig. 5.

The compressed air used in the caissons was taken directly from the pipes of the Popp system near by. The caissons were lighted by electricity from plants established at the works on each bank. The depth of the cutting edge of the caisson below ordinary level of the water was about 30 ft.

The details of the descent of the caissons are graphically shown in Exhibit F 7.* Some details of the granite foundations of the skewbacks, the weights, lines of thrust, etc., appear in Exhibit F 8.*

The ornamental features of the four towers appear in Exhibit F 9.*

* These exhibits are not reproduced herein, but are on file in the Library.



The four sitting figures are to represent the four periods of French history, Charlemagne, Louis XIV, the early and the later Republics.

The engineers, Messrs. Résal and Alby, are from time to time writing the history of the work in the *Annales des Ponts et Chaussées*, and at the recent Fiftieth Anniversary of the French Society of Civil Engineers they gave a general description which will soon appear in its *Bulletins*.

As a matter of interest, in comparing this bridge with the Mirabeau Bridge, further down the river, Mr. Alby has presented photographs of that bridge, with a description of the same which appears as Exhibit I*.

Some of the printed matter from which the above brief description is taken is found in No. 6 and No. 27, pages 165-214 and 311-328, respectively, of the *Annales des Ponts et Chaussées* of 1898. Further descriptions by the same writers are to follow.

The arched platform hanging from the rolling bridge was ready for the erection of the arch members about November 10th, 1898, when the work of placing the permanent arch ribs was begun.

THE EXTENSION OF THE ORLEANS RAILROAD TOWARD THE EXPOSITION GROUNDS.

The new station at Quai d'Orsay at the level of the tracks is shown in Plate VIII. Outside of the plans there are, however, a few points to be noted.

Originally, all the Paris railway terminals were in the faubourgs, outside the city proper. To-day the stations of the Northern, Eastern and Western railways are within the city, but it is because the city has grown in these directions. Originally, they were surrounded by cultivated land, and the St. Lazare station, now in the very center of the city, was in quite a picturesque quarter, to which had been given the name "Old Poland."

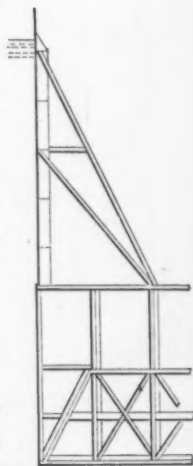


FIG. 5.

* These exhibits are not reproduced herein, but are on file in the Library.

Rue

Rue
du
Bac

CAISSE DES DÉPÔTS
ET CONSIGNATIONS

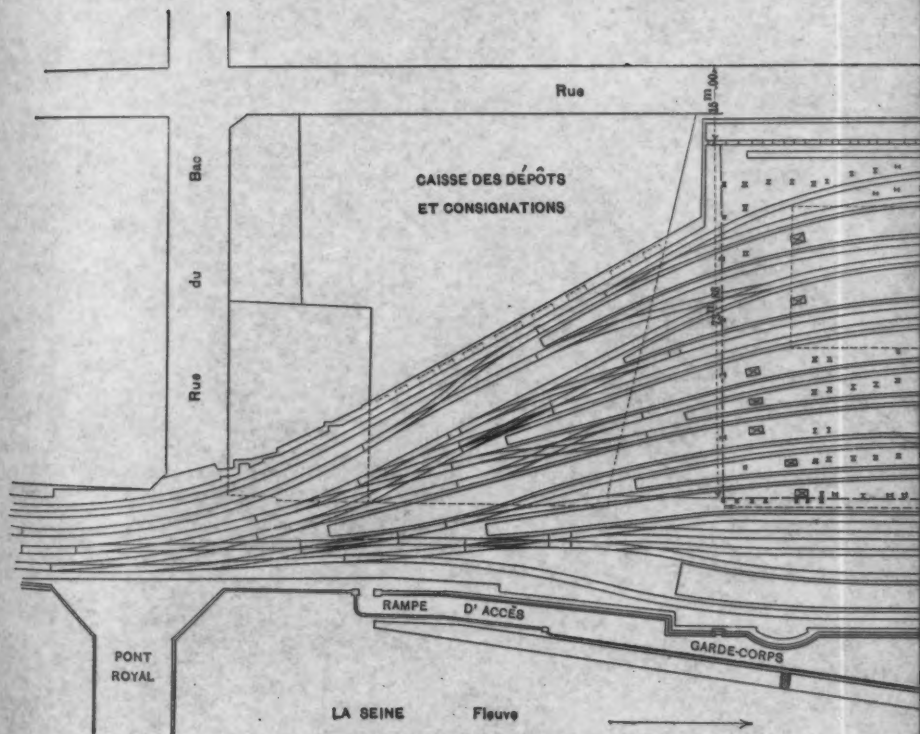
PONT
ROYAL

RAMPE
D'ACCÈS

GARDE-CORPS

LA SEINE

Fluve



Rue de
Poitiers

de

Lille

de

CAVES

BASSIN DE PUIPAGE

DE

L' HÔTEL

CAVES

DE

L' HÔTEL

Banlieus

Arrivée des Grandes Lignes

Banlieus

T bicyclettes

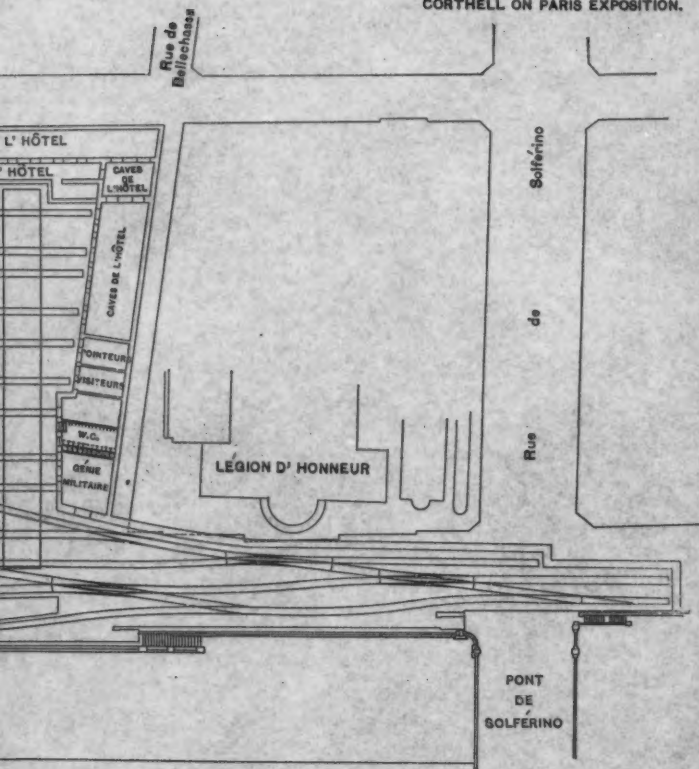
Départ des Grandes Lignes

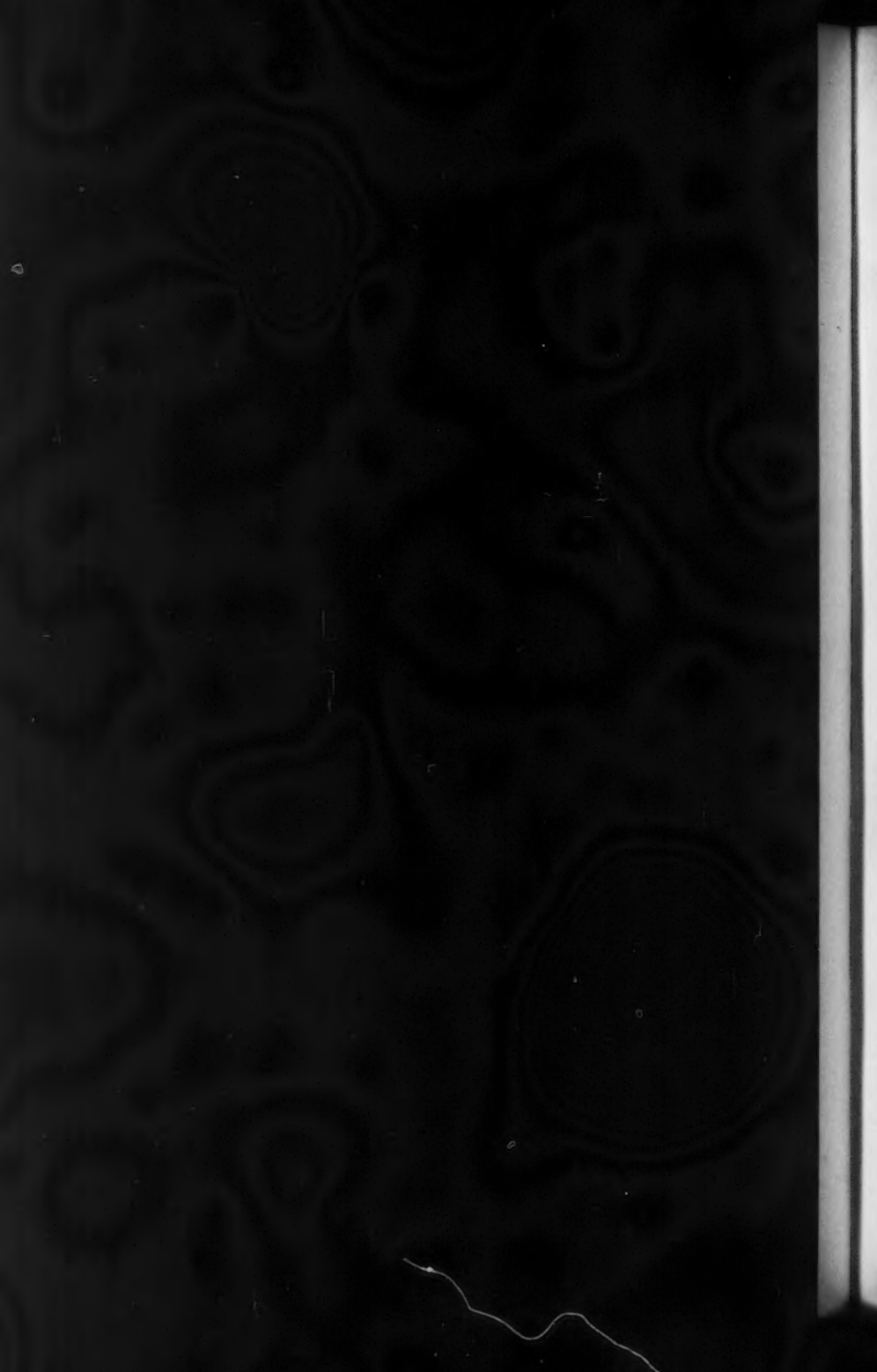
T bicyclettes

Départ des Grandes Lignes

GARDE-CORPS

PLATE VIII.
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 CORTHELL ON PARIS EXPOSITION.





Mr. Brière, Chief Engineer of the Work, in some remarks before the French Society at its recent Fiftieth Anniversary, stated that great cities generally grow toward the north and west. The terminal station of the Orleans Railroad was in the east and south, in a region where the population has not developed. It was obliged to approach the center, and was encouraged to do so by the success which attended the subway extension of the Chemin de Fer Sceaux to the Luxembourg station. The old terminal station of this line had 3 000 000 passengers in 1894, the new station had 4 800 000 in 1896, and 7 000 000 in 1897.

The difficulty with the Orleans extension was to find for the station a place which should have about 30 000 sq. m. (322 900 sq. ft.). However, a suitable location was found by purchasing and removing the ruins of the old "Cour des Comptes," which had been a caserne or barracks. At the side of it was another State building, "La Casse des Dépôts et Consignations," which could neither be moved nor disturbed. It was therefore necessary to go under it. The author has, with the resident engineers in charge, examined this difficult work, by which an extensive area under the corner of this building is being prepared for the tracks branching out into the subterranean station.

The whole line is about 4 km. (2.48 miles) in length. In the map of Paris, Plate VI, this extension is shown by a heavy dotted line. The map of the Exposition, (Fig. 1), shows on the margin the location of the terminal station, which is about as far from the Gare des Invalides as the Opera House is from the Madeleine.

The extension traverses the present terminal station. The grades to reach the subway are very light. For the entire distance the extension is along and adjacent to the quay walls of the Seine, directly under the quay streets and very near to the surface of these streets, often not more than 18 ins. below them.

Generally, the municipal government has prohibited open cuttings in the streets and covering them afterward with metallic floors on columns. Therefore, tunneling is required, and this is being done by means of a hydraulic shield. It is noticeable, however, that in several places the pavement was disturbed to such an extent that, while work underneath was going on, it was necessary to guard the areas with ropes to keep off vehicular traffic, and that the surface had to be raised and repaired. Two typical sections are shown in Fig. 6.

The rails are laid at about the ordinary level of the water of the

Seine. In floods the water rises nearly to the level of the top of the subway, sometimes 5 m. (16.4 ft.) above the ordinary level. As there is a comparatively thin wall between the subway and the river, it is necessary to make a tight dam of this wall, and also, generally, to lay

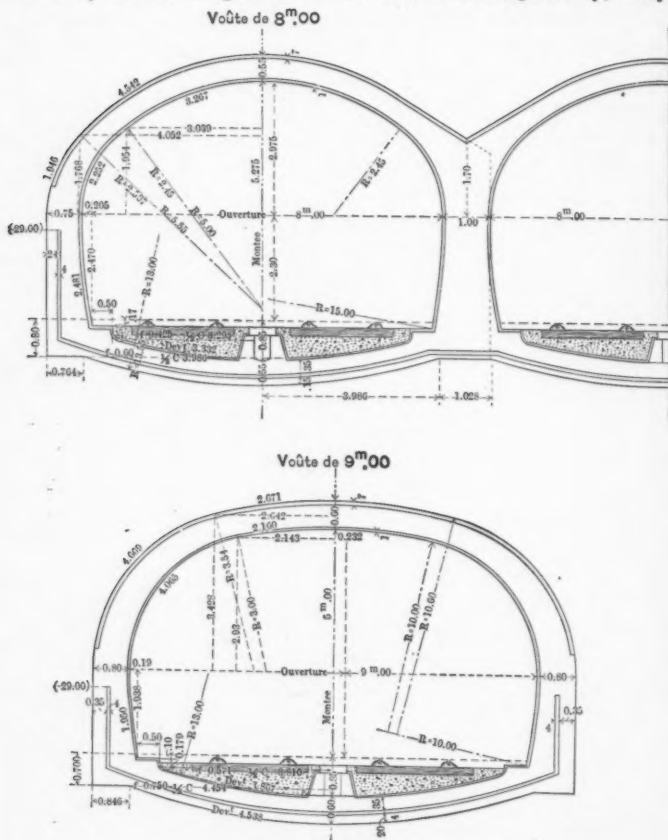


FIG. 6.

a very thick invert of béton to resist the upward pressure and the percolation in times of flood. Probably it will be necessary to install pumping plants for these occasions.

At one point, where new quays for river passengers and merchant-

dise had to be provided, the work was done in open trench for about 650 m. (2 132 ft.). Of this work, approximately 55% has a masonry arch, 31% has a metallic floor, and 14% is in open trench. (These proportions are somewhat in doubt.) In the open-trench work the width of the cross-section is 9 m. (29.5 ft.), 8 m. (26.24 ft.) being for the tracks and 1 m. (3.28 ft.) for the employees. At the junction with the Sceaux Railroad, which had to be provided for, there are four tracks, in two tunnels, each 8 m. wide. Elsewhere there are two tracks. The two tunnels communicate with each other by wide bays. For aeration, and also for light, the walls of the Seine are pierced above the flood level.

There will be one intermediate station between the present terminal and the new station at the Quai d'Orsay. It will connect with the banlieue line (ceinture), and will be about 11 m. (36.09 ft.) wide.

In the new terminal station, Plate VIII, there will be fifteen tracks, common to arrivals and departures. The shortest platform is 240 m. (787.4 ft.) long, and is at the level of the platforms of the cars, 88 cm. (34.64 ins.) above the rails. The baggage will be handled on separate platforms, which are 3.50 m. (11.48 ft.) wide, with elevators for lifting or lowering the baggage. The tracks at the further end of the station are all connected by turn-tables, 6.20 m. (20.33 ft.) in diameter. The length of the ground floor for passengers is 200 m. (656 ft.). All the departure service is done on the Quai d'Orsay, the arrival service on the Place Belle-Chasse. It is impossible to provide a court for departures, but a widening of the space is made. The arriving passengers, on ascending to the ground floor from the level of the platforms, will find a carriage court 100 m. (328 ft.) long and 50 m. (164 ft.) wide, where the carriages are stationed.

Over the station there is to be a hotel of considerable proportions. It will have a dining room of 420 sq. m. (4 519.2 sq. ft.), a salon 300 sq. m. (3 229 sq. ft.), galleries of 150 sq. m. (1 614 sq. ft.), a grande salle des fêtes of 450 sq. m. (4 842 sq. ft.), and 275 chambers. The entire structure is carried on metallic supports. It was necessary to divert a great many sewer, water and gas pipes, etc. One intercepting sewer, about 4 m. (13 ft.) in diameter, that passed directly through the new station ground, had to be diverted, at a cost of 5 000 000 francs (\$1 000 000). This sewer received all the water of the left bank and conducted it to the siphon of the Place de la Concorde, under the Seine.

The traction will be electric. The engineers and experts visited the United States and made special examinations of the electric tunnel line in Baltimore. They returned with the conviction that it would be possible, easy and economical to make an application of electric traction with a full-sized train, such as run from Paris to Bordeaux, and on the Circular Line of Paris.

They are, however, still studying the question, but everything now favors the use of separate special electric motors, changing from the steam locomotive at the Quai d'Austerlitz, the present terminal for the extension to the Quai d'Orsay.

The cost of the entire work will be about 40 000 000 francs (\$8 000 000), or 10 000 000 francs per kilometer. The expenses are divided about as follows:

Personnel	1 000 000 francs.	\$200 000
Land.....	13 000 000 "	2 600 000
Disturbance of streets, etc.....	1 000 000 "	200 000
Sewers	5 000 000 "	1 000 000
Water and other conduits.....	500 000 "	100 000
Principal construction.....	10 500 000 "	2 100 000
Tracks and ballast.....	1 000 000 "	200 000
Buildings.....	8 000 000 "	1 600 000
<hr/>		
Total	40 000 000 francs.	\$8 000 000

The work will no doubt be completed before the opening of the Exposition.

THE EXTENSION OF THE WESTERN RAILROAD TO THE EXPOSITION.

The route of this improvement and extension is shown on the map of Paris (Plate VI). The terminal at the Champs de Mars is shown on the map of the Exposition (Fig. 1).

From the St. Lazare Station to Station Courcelles, which is a junction station of the belt line, there are four tracks; from this station only two.

The great additional traffic of the Exposition has made it necessary to place two more tracks from Station Courcelles to the point in Passy, where the new line, also a double-track line, is to leave the main line for the Exposition. Some features of this four-track work are quite

ENCORBELLEMENTS EN BETON ARMÉ
SYSTÈME HENNEBIQUE

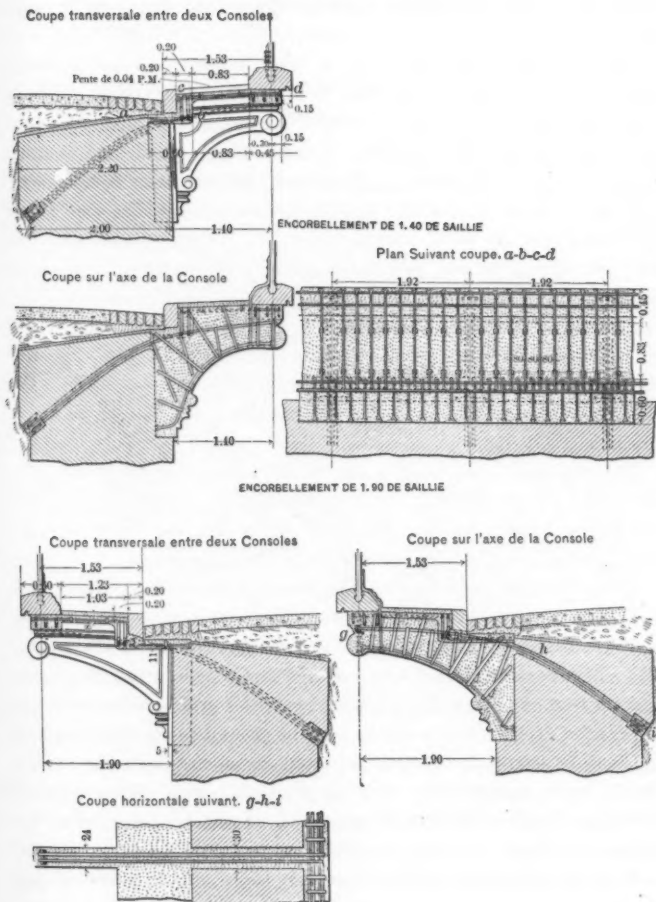


FIG. 7.

difficult, requiring veritable tunnels under such avenues as the Bois de Boulogne and Grande Armée. It should be understood that the entire line from the St. Lazare Station is depressed. Hitherto, from Courcelles to Passy, there was a simple excavation, with the usual earth slopes and with a railing on the edge, as the line runs through an avenue.

To accomplish the widening it was necessary to build nearly vertical retaining walls. As this work infringed on the sidewalks in some localities, particularly at Station Courcelles, the plan of projecting sidewalks has been adopted. The peculiar method used is illustrated in Fig. 7. On buildings, such work had previously been done by architects, but it is believed by the railway engineers that this is the first instance of its use on railway work. It is simply a concrete sidewalk of varying width, resting on concrete brackets of ornamental shape anchored into the retaining wall by round rods extending from the front of the bracket through it to take hold of similar rods, which are imbedded in the wall, and run lengthwise with the sidewalk. Strap-iron is also used to connect the upper and lower rods of the brackets. The maximum overhang to the line of the railing, or fence, is 1.90 m. (6.22. ft.)

The city authorities require very severe tests to establish the absolute safety of the sidewalk. A heavy weight is dropped several feet and several times upon the outer part of the greatest overhang. No starting of the work has yet been noticed under these tests.

At the point of departure of the Champs de Mars Line the main line is in a very deep excavation. In order to avoid a level crossing, the right-hand track of the extension is carried under the tracks of the main line. This requires deep tunneling, and both lines, after they come together from the single tunnels and enter the double-track tunnel, are still carried deep under the surface of the ground to near the Seine.

It will be seen from the plan and profile,* that the line, after coming into the open, curves to the left in crossing the river. The trusses of the bridges and viaducts are quite well shown on the profile; the longest span, that over the navigable way, is quite artistic. All the work is well advanced and there appears to be no good reason why it will not all be ready for traffic before the opening of the Exposition. At the Champs de Mars station it was necessary to buy considerable

* These exhibits are not reproduced herein, but are on file in the Library.

property and demolish quite a number of houses to obtain the room required. After the Exposition, this station, with its numerous tracks, will be used for a general freight yard, and it may possibly become the terminus of a line from this point to Versailles, proposed by the company. The cost of the work being done by the Western Railroad will be about 25 000 000 francs (\$5 000 000).

THE PLATEFORME MOBILE (MOVABLE SIDEWALK) AND ELECTRIC RAILROAD.

It was not the original intention to make the entire circuit of the grounds, but by examining the sketch of the grounds, Fig. 1, and the small diagram of the movable sidewalk, Fig. 8, it will be seen that

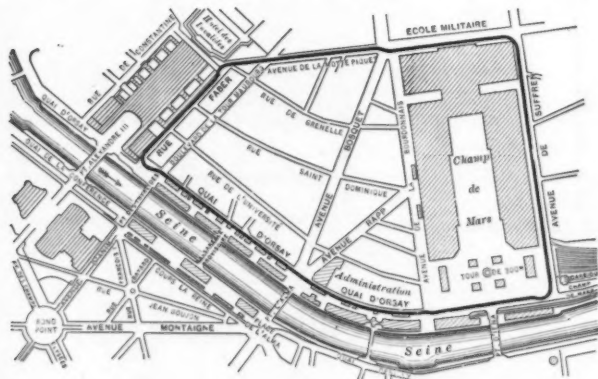


FIG. 8.

the later plans require an entire circuit. The following is a translation of extracts, nearly entire, of three articles in *Le Génie Civil*, and the illustrations are taken from these articles.

These descriptions give the entire matter so fully that it is unnecessary to dwell upon the subject.

The author has obtained from the office of the President of the company organized to exploit the "plateforme mobile," the information that the whole matter is in an experimental condition; a short section of 300 m. (984 ft.) is now being installed for trial at St. Oure, just outside of Paris. A demonstration of the practicability, safety and convenience of the plan is required by the Exposition authorities, by

the terms of the concession given to the Engineer, M. de Mocomble and his associates. It will appear from an examination of the plans that they differ essentially from those of the Chicago movable sidewalk, which is so well known that a description here is unnecessary. Whether the defects attributed to it by the Paris engineers are real or important will not be discussed, and whether the new plans to remedy them may not possess defects as serious will be demonstrated by the experiments, or at least by the actual transportation at the Exposition.

"Project for a Moving Electrical Sidewalk for the Transportation of Passengers in the Interior of the Exposition.—It was not until 1893 that there existed a practical test of the above idea. This was the in-

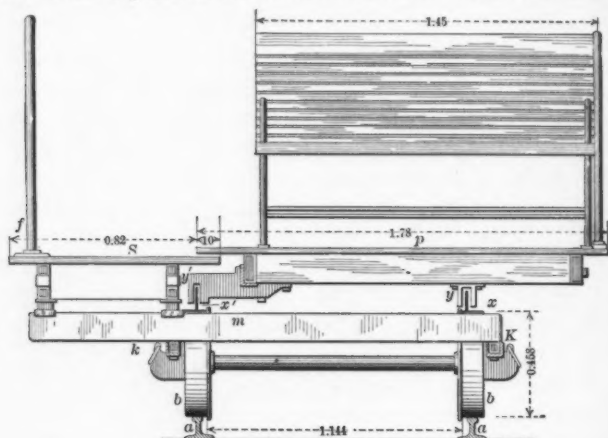


FIG. 9.

stallation by two American Engineers, Messrs. Silsbee and Schmidt, of the first movable sidewalk at the Chicago Exposition. This sidewalk had two rates of speed; that is to say, it consisted of two parts, one moving at a speed of 5 km. (3.1 miles) per hour, and the other at a speed of 10 km. (6.2 miles) per hour. It is certain that in this system it would not be more difficult to go from the first platform to the second than it would to go from the stationary sidewalk to the platform moving at the rate of 5 km. an hour. The method employed to obtain two different rates of speed consisted in placing the second platform upon the rims of the wheels of the first platform by means of flexible rails. Thus, by the same movement, two rates of speed were obtained, of which one was double the other (Fig. 9).

"This system served very well at the Chicago Exposition in 1893, and at that of Berlin in 1896, which may be considered the time of its real practical demonstration.

"*Movable Sidewalk of Messrs. Blot, Guyenet and Mocomble.*—In spite of the good results that it has given, the movable sidewalk of Messrs. Silsbee and Schmidt presents, from a technical point of view, certain defects which have attracted the attention of Messrs. Blot, Guyenet and Mocomble, construction engineers of Paris. One principal defect consists in having all its machinery in motion, which makes the care very difficult and does not permit repairs unless the entire machinery is stopped. Another objection is that the moving rails supporting the second platform constitute, together with the axles and the machinery, a dead weight put in motion uselessly, and, the system not riding easily, the movement lacks smoothness. Finally, as there is only one moving truck in thirty-six, the moving carriage must be ballasted to aid the adhesion, and thus the system does not in reality have its load

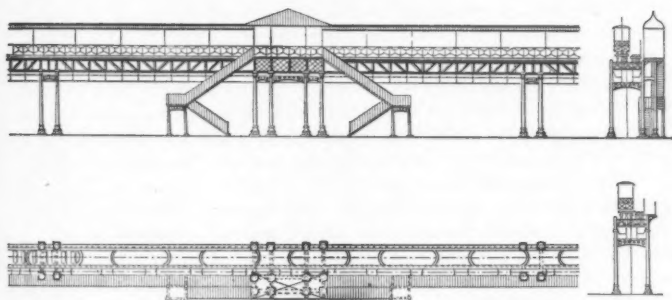


FIG. 10.

uniformly distributed, but is a system of traction by locomotives placed at intervals in a series of cars forming a continuous train.

"In the moving sidewalk proposed for the Exposition of 1900, Messrs. Blot, Guyenet and Mocomble are endeavoring to remedy the faults enumerated above, and we shall endeavor to describe clearly the solution at which they have arrived.

"The whole of the projected installation comprises:

"*First.*—A platform at a higher rate of speed 1.30 m. (4.26 ft.) wide rolling on a track with a gauge of 0.90 m. (3 ft.) at a speed of 2.70 m. (8.85 ft.), a second, that is 9.720 km. (6 miles) an hour (Figs. 10 and 11).

"*Second.*—A platform at a lower rate of speed, 0.80 m. (2.62 ft.) wide, rolling on a track with a gauge of 0.45 m. (1.47 ft.), at a speed of half that of the first (Fig. 10).

"*Third.*—A stationary sidewalk 0.90 m. (3 ft.) wide.

"*Fourth.*—A metallic structure supporting the whole, and resting on metallic columns.

"*Fifth.*—Stairs for the ascent and descent of passengers.

"Each of the platforms is composed of trucks belonging to two distinct types. The first is supported by four independent wheels, while the second has no wheels, and rests on the neighboring trucks. The floor of each truck rests on wooden beams carried by cross-pieces which are fastened at the center to an axial girder, which is the core of the system. These cross-pieces carry at their extremities the wheels which rest on an iron track fastened to the wooden beams carried by the metallic cross-pieces, which are bound to the main girders.

"The axial girder rests, every 6 m. (19.6 ft.), on rollers, sometimes moving and sometimes for support. It consists of plates and angle-bars, with a steel rail in the form of an inverted T (Fig. 11), that is to say, having the flange at the bottom. In order to permit it to pass the curves this girder is divided into sections of 4 m. (13.1 ft.) joined together by hinges.

"The motion is produced by the adhesion of the axial girder on the moving rollers, the same axle-tree being used for both platforms. In order to remedy the sagging which would take place between the rollers, these are mounted on a short axle, held solidly between two bearings as close together as possible and resting on an elastic frame. These two bearings are united by an axle-tree and two Cardan joints, thus allowing for every vertical displacement of the rollers.

"The moving rollers are placed 39 m. (127 ft.) apart, and the supporting rollers 6 m. (19.6 ft.) apart. The motive power, furnished by an electric current, being thus distributed to a large number of points, it is not necessary to overcharge to induce adhesion at the motive points. On the other hand, the constructors have taken all precautions, so that the movement may be as quiet as possible. The wheels of the trucks, as well as the rollers, are covered with rubber, thus deadening the shock and the noise, and we might suggest wheels of compressed paper to do away with all noise.

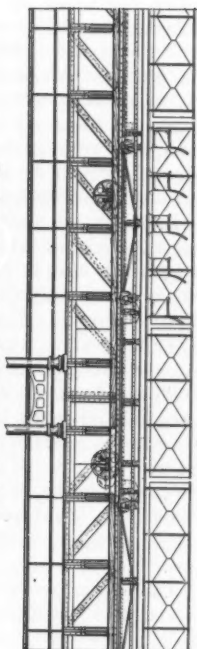
"Iron posts 1 m. (3.28 ft.) in height have been fastened to the floor of the trucks of the first platform to serve as a support to inexperienced travelers in passing from the stationary platform to the moving one. In going from this latter to the fastest platform, the backs of the seats will be of assistance. Every 200 m. (656 ft.) there are stairways for the ascent and descent of passengers.

"In the arrangements everything has been planned to insure a continuous and uninterrupted movement. To this end the wheels of the trucks, the moving axles and the axial girders have been calculated in such a way that one portion might be missing without making it necessary to stop, or that the neighboring portions should suffer.

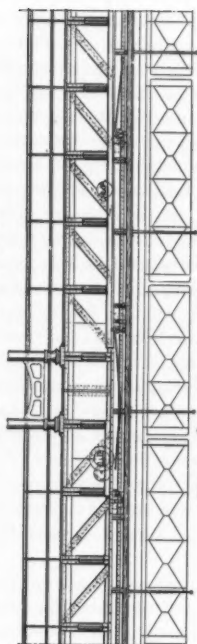
"The moving platforms and the stationary sidewalk rest on main

PROJET DE PLATEFORME MOBILE ELECTRIQUE ET A DEUX VITESSES.

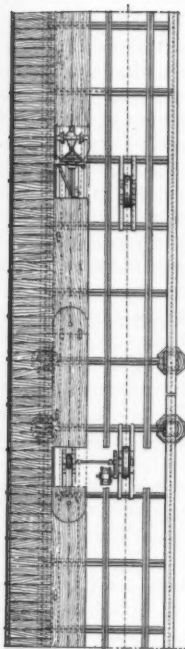
Plateforme grande vitesse. (Elevation longitudinale.)



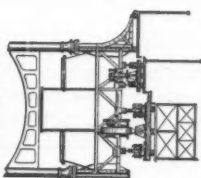
Plateforme petite vitesse. (Elevation longitudinale.)



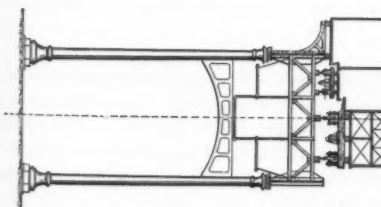
Plateforme petite vitesse. (Plan)



Coupe transversale.



Coupe transversale.



girders, braced 1.20 m. (4 ft.) apart, and supported by iron open-work columns, spaced at 19.50 m. (64 ft.) from axis to axis.

"This aerial disposition of the platforms surely presents very alluring inducements, for it permits a complete tour of the Exposition and furnishes travelers with extremely varied panoramic views.

"Unfortunately, these advantages are too dearly bought, for the aerial platform brings with it serious inconvenience. Far from allowing passengers to get on at all points, as would a platform on the ground, it is necessary to make stations, where great crowds would collect, and, by the consequent ascending of stairs, it deprives passengers of a part of the advantages it gives them. And more, and this is without doubt the most serious difficulty, this aerial platform, although light and elegant as it is expected to be, would form a line cutting all perspectives. It is to be feared that it will have against it the opinion of most of the artists called to give their advice, and who would prefer, perhaps, to deprive visitors of a very commodious and agreeable method of transportation rather than admit a construction capable of breaking more or less the harmony of the complete whole which they purpose creating.

"This said, one must recognize that the installation presented by Messrs. Blot, Guyenet and Mocomble is a project carefully studied and perfectly possible of realization, at least from a technical point of view.

"The projected course (Fig. 8) would pass by the Avenue de La Motte-Piquet, l'Esplanade des Invalides, the Quai d'Orsay and Avenue de Suffren, thus forming a closed circuit of about 4.200 km. (2.6 miles).

"The originators of the project, such as has been described, estimate that this platform could take care of a traffic of 50 000 passengers an hour, allowing, on one hand, four passengers per running meter, which would give at first: $4 \times 2.70 \text{ m.} \times 3\,600 = 38\,880$ places, and, on the other hand, most of the passengers, in place of going the whole course, will not go more than two or three kilometers, which will leave about 25% of disposable places, and would increase the number of passengers an hour to $38\,880 \times \frac{100}{75} = 51\,840$.

"Even when these figures are submitted to a proportionate reduction, one is struck with the great capacity for traffic that such an installation would possess. This capacity could also be increased in such a manner as might be deemed necessary by a simple increase in the width of the high-speed platform, the other parts remaining the same, or being but slightly modified.

"Messrs. Blot, Guyenet and Mocomble place the cost at about 6 000 000 francs (\$1 200 000) for the initial setting up of their installation. They add to this sum about 1 500 000 francs (\$300 000) for the

running expense during the Exposition, and for the interest on the capital, and show that, with these conditions, in order that the enterprise be remunerative, it would be necessary to carry only 15 400 000 passengers at the uniform price of 0.50 franc (10 cents). If it is assumed that the duration of the Exposition will be 180 days, that would make a little less than 85 000 passengers per day. The Decauville Railroad of the Exposition of 1889, whose course was very much shorter, and whose traffic capacity was much more limited, carried on an average 33 640 passengers a day.

"The calculations relative to the exploitation have been based upon the supposition that the electric current will be furnished by one of the sectors of the City of Paris at the price of 0.06 franc (1.2 cents) per hecto-watt-hour. Also, a study of the conditions through which the platform will pass has led the constructors to admit that, fully charged, the resistance to the movement will be 5 kgr. (11 lbs.) per running meter, so that the whole of the installation will require $\frac{4\,200 \times 5}{75} = 280$ H.-P. measured by the moving rollers. Allowing

only 80% for the estimated power furnished at the receivers and 10% for leakages on the line, the necessary force at the power station would be about 400 H.-P., reduced to 170 H.-P. for the unloaded platform.

"It should also be remarked that the starting would occasion an extra effort of about 20%, but this increase of labor would last only a few seconds a day, and it is not necessary to take it into account in the calculations relative to the expenses of the exploitation."

"This project, undertaken with the technical collaboration of Mr. Henri Maréchal, Engineer of the Ponts et Chaussées, is backed by the General Traction Company and the International Bank of Paris.

"It comprises a single-track electric railroad, having a gauge of 1 m. (3.28 ft.), and an electrical platform at two rates of speed (Plate-forme mobile).

"The railroad follows in design the stipulated course, but some modifications in the specifications have been required, namely, that the cross-roads, Rapp-Bosquet, be passed on a viaduct, and that the carriages be 3.15 m. (10.1 ft.) high and 2.50 m. (8.2 ft.) wide.

"The above will comprise eight trains in use and three in reserve, each having 250 places. Each train will require 140 H.-P. The current will be distributed the entire length of the track by a central rail.

"The contractor requests that the power station producing the electricity be placed within the confines of the Exposition.

"The platform, which will make the circuit in an opposite direction to the railroad, is the Blot, Guyenet and Mocomble system, recently described in *Le Génie Civil* (as above). The whole comprises a fixed sidewalk, a first platform moving at the rate of 5 km. (3.1 miles) an hour, and a second moving at double that rate of speed.

"The platform would be continually on a viaduct. Parallel or placed above the railroad, Avenue de la Motte-Picquet, Rue Faber and Quai d'Orsay, it would cross the Avenue de La Bourdonnais, and continuing, on this Avenue, along the buildings of the Exposition, it would be at the level of the second floor.

"Independently of the advantages which would result from this course, in respect to the enlargement of the different parts of the Exposition, the contractor places the combined capacity of the two systems at 50 000 or 60 000 passengers per hour. He says, besides, that the platform would be an attraction for the visitors to the Exposition.

"The tariff agreed upon is: Railroad, one and only class, 0.25 franc (5 cents); platform, one and only class, 0.50 franc (10 cents).

"The rent to go toward the receipts of the Exposition would be 1 centime (0.2 cent) per person carried by the railroad or by the platform.

"The railroad would be finished at the date fixed by the specifications, and the platform on March 1st, 1900."

"The Minister of Commerce and Industry is about to sign a concession for an electric railroad for the transportation of passengers in the interior of the Exposition of 1900. Among the five projects which have been submitted to the Commission having charge of the transportation department, the preference has been given to that of Mr. Mocomble. It is certainly the most original, and it also has the greatest transportation capacity.

"We will sum up briefly what the project, which has been worked up with the technical collaboration of Mr. Maréchal, Engineer of the Ponts et Chaussées, comprises: *First*, an electric railroad taking the current from a lateral rail, and moving in one direction on a course which forms, as is well known, a closed circuit; and, *second*, a moving platform at two rates of speed, and moving in an opposite direction from the railroad.

"This platform will carry a stationary sidewalk from which access can be had to the first platform, moving at a rate of 5 km. per hour; from this one can pass to the second platform, moving at double that rate of speed.

"The authors of the project attribute to the two combined methods of transportation a capacity of 50 000 to 60 000 passengers per hour.

"Conforming to one of the articles of the convention approved by the Minister of Commerce, a joint stock company will be formed in place of the holder of the concession. This company will take the name: 'Electrical Transportation Company of the Exposition,' and must proceed within six months with a trial of the moving sidewalk system adopted, on a closed circuit of 300 to 350 m. (984 to 1 148 ft.)."

THE METROPOLITAN UNDERGROUND ELECTRIC RAILWAY.

The routes of this railway, under its rights granted by the Municipal Government of Paris, are shown in heavy solid lines on the General Map of Paris (Plate VI). Much of this work is now under way. It is not expected that the entire system will be completed before the opening of the Exposition, but those lines leading from the railway stations to the Exposition, and connecting the stations, will no doubt be ready for operation at that time. The whole system comprises from 35 to 40 miles.

The construction requires the relocation and reconstruction of sewers, water and gas pipes, electric conduits, etc. No work can be done in open cut; all must be in tunnel. This makes the work very expensive and very slow. The work is not generally very deep below the street surface. The material is good for excavation and handling, and is removed as fast as brought up from the shafts. Much of the work of carting it away is done at night. The plans generally contemplate two single-track tunnels of small dimensions. The single-car system will be used, and the traction plan will be by trolley, like the Boston subway. There is no connection with the railways, nor can there be any. The gauge is intentionally made different, and also the levels and other features. The fear that the railways might at some time get authority to run their cars into the city led the City Government to take steps at the outset to prevent it.

Paris depends largely upon its octroi duties for its income. Although its debts are large, its wealth in property is immense, and is said to be equal to that of some of the smaller kingdoms of the continent, like that of Portugal and Denmark.

The convenience of the people is a lesser consideration than the financial interests of the city. It is one of the principles of the Paris Government to keep the people within the area of the city proper. The octroi plan accomplishes this purpose; consequently, the districts

outside of the old line of fortifications do not build up to any great extent and there is, therefore, no great suburban business upon the railroads.

The details of the Metropolitan Railway plans have not been received by the author in time for this paper.

THE ENLARGEMENT OF THE GARE DE LYONS, OF THE PARIS, LYONS
AND MEDITERRANEAN RAILWAY.

The station is now being entirely remodeled at very great expense, said to reach \$8 000 000. The new train-shed is completed, the work having been begun about two years ago. The plans for the main structure have just been approved, and work upon it will soon be begun. It will be very extensive and will be, when completed, the finest and most commodious station in Paris.

EXHIBITS.

The following exhibits accompanied the description of the approaches and transportation facilities of the Paris Exposition of 1900, and are filed in the Library of the Society.

- Exhibit A. —Plan Général. Exposition Universelle de 1900.
- “ B. —Vue d'Ensemble de l'Exposition de 1900. (Reproduced as Plate V.)
- “ C. —Plan de l'Exposition Universelle de 1900. (Reproduced as Fig. 1.)
- “ D. —Outline Plan of Paris. (Reproduced as Plate VI.)
- “ E. —Elevation et Coupe Transversale du Pont Alexandre III. (Reproduced as Plate VII.)
- “ F. —Two Pamphlets, “Notes sur la Construction du Pont Alexandre III,” par M. M. Résal et Alby. Nos. 6, 27 and 39 of the *Annales des Ponts et Chaussées*. Including 11 plates, of which two are reproduced as Figs. 2 and 3.
- “ F, 1.—Ancien Pont Suspendu des Invalides.
- “ F, 2.—Construction du Pont Alexandre III. Elevation and sections.
- “ F, 3.—Plan du Pont Alexandre III (reproduced as Fig. 4).
- “ F, 4.—Détails des Caissons et des Échafaudages pour la Construction des Culées.
- “ F, 5.—Vue de la Caisson de la Rive Droite à la fin du Montage.
- “ F, 6.—Montage du Caisson de la Rive Droite.
- “ F, 7.—Graphiques de la Déscent des Caissons.
- “ F, 8.—Details of Masonry Abutments.
- “ F, 9.—Façade Latérale de la Culée.
- “ G, 1.—Prolongement de la Ligne d'Orléans au Quai d'Orsay. Plan Général.
- “ G, 2.—Profil en Long.
- “ G, 3.—Profils en Travers Principaux.
- “ G, 4.—Gare du Quai d'Orsay. (Reproduced as Fig. 6.)
- “ G, 5.—Gare du Quai d'Orsay. Plan au niveau du rez-de-chaussée.
- “ G, 6.—Gare du Quai d'Orsay. Plan au niveau des voies. (Reproduced as Plate VIII.)
- “ H, 1.—Chemin de Fer de l'Ouest, Ligne de Courcelles-Centure à Passy, et au Champ de Mars. Plan général.
- “ H, 2.—Profil en long.
- “ H, 3.—Encorbellments en béton armé, Système Hennebique. (Reproduced as Fig. 7.)
- “ I. —Pamphlet, “Notice sur la Construction du Pont Mirabeau. With two photographs.
- “ J. —“Le Prolongement de la Ligne de Sceaux vers l'intérieur de Paris.” Par A. Brière et Henri de la Brosse. Paris, 1895. Vol. 1, Text; Vol. 2, Plates.